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(Reaffirmed 2002)

Indian Standard

SPECIFICATION FOR ELECTRICAL INSTALLATIONS IN SHIPS

PART 3 EQUIPMENT

Section 12 Choice and Installation of Cables for Low-Voltage Power Systems

UDC 629·12·066 : 621·315·2·027·2

Indian Standard

SPECIFICATION FOR ELECTRICAL INSTALLATIONS IN SHIPS

PART 3 EQUIPMENT

Section 12 Choice and Installation of Cables for Low-Voltage Power Systems

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Indian Standard

SPECIFICATION FOR ELECTRICAL INSTALLATIONS IN SHIPS

PART 3 EQUIPMENT

Section 12 Choice and Installation of Cables for Low-Voltage Power Systems

0. FOREWORD

0.1 This Indian Standard (Part 3/Sec 12) was adopted by the Indian Standards Institution on 17 February 1986, after the draft finalized by the Electrical Equipment and Installations in Ships Sectional Committee, had been approved by the Electrotechnical Division Council.

0.2 This standard is one among the series of Indian Standards on electrical installations in ships. This series consists of the following parts:

Part 1 General,

Part 2 System design,

Part 3 Equipment,

Part 4 Installation and test of completed installation, and

Part 5 Special features.

0.3 In Part 3, for case in reference, sections 10 to 19 have been reserved for the low and medium voltage power cables while sections 20 to 29 would deal with telecommunication cables for use in ships.

0.4 This standard (Part 3/Sec 12) deals with choice and installation of cables for low-voltage power systems. Other sections dealing with low voltage power cables are as follows:

Part 3/Sec 10 Low voltage cables for power systems : Section 10 General (*under preparation*)

Part 3/Sec 11 Low voltage cables for power systems : Section 11 Insulating materials

0.5 In the preparation of this standard, assistance has been taken from IEC Pub 92-352 (1979) : Electrical installations in ships; Choice and installation of cables for low-voltage power systems issued by International Electrotechnical Commission.

0.6 This part of the standard shall be read in conjunction with the other parts mentioned in **0.2.**

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part 3/Sec 12) lays down the basic requirements for the choice and installation of shipboard cables intended for low-voltage power systems at voltages up to and including 1 000 V.

SECTION 12A CHOICE OF THE CABLES

2. CHOICE OF THE INSULATION

a) The rated voltage of any cable shall not be lower than the nominal voltage of the circuit for which it is used, and

b) The rated operating temperature of the insulating material shall be at least 10°C higher than the maximum ambient temperature likely to exist, or to be produced, in the space where the cable is installed. Cables installed in engine room and boiler room shall have an insulation of at least 75°C class.

3. CHOICE OF PROTECTIVE COVERINGS

a) Cables fitted on decks exposed to the weather, in damp and wet situations (for example, bathrooms), in cargo holds, in refrigerated spaces, in machinery compartments and, in general, where water condensation or harmful vapours (including oil vapour) may be present, shall have an impervious sheath.

NOTE — PVC, CSP and PCP sheaths are considered as impervious in this context, although not suitable for permanent immersion in liquids.

b) In choosing different types of protective coverings, due consideration should be given to the mechanical actions to which each cable may be subjected during installation and in service. If the mechanical strength of the protective covering is considered insufficient, the cable should be fitted in pipes or conduits or trunking or be otherwise protected (*see* **17**).

*Rules for rounding off numerical values (*revised*).

c) For single-core cables to be used with alternating current (*see* in addition **28**).

d) Cables should have 'flame-retardant' or 'fire-resisting' characteristics*.

NOTE — Attention is drawn towards the necessity of introducing cables having sheathings with limited fire hazard and produce limited levels of obnoxious fumes, smoke and corrosive products for use in ships. Brief notes on limited fire hazard sheathing material for cables are given in Appendix A.

e) For switchboards heat-resistant PVC insulated single-core cables without further protection, complying with the specification for insulating materials and keeping in view the ambient temperature may be used.

4. CABLES FOR FIRE-DETECTION AND FIRE-EXTINGUISHING SERVICES

4.1 In circuits used for fire alarm, detection, extinguishing services, remote stopping and similar control circuits, the use of fire resisting cables shall be considered unless:

a) the systems are of self-monitoring type or failing to safety, or

b) the systems are duplicated.

5. DETERMINATION OF THE CROSS-SECTIONAL AREAS OF CONDUCTORS

5.1 The cross-sectional area of each conductor should be large enough for the following conditions to be complied with:

a) The highest load liable to be carried by the cable should be calculated from the load demands and diversity factors of circuits, machinery, etc, supplied by the cable [*see* IS : 10242 (Part 2/ Sec 1)-1982† *and* **11**].

The 'corrected current rating' of each cable should be not lower than the highest current likely to be carried by the cable concerned.

The 'corrected current rating' is calculated by applying the relevant correction factors (*see* **7**, **8** and **9**) to the 'current rating for continuous services' given by Table 1 and **6**.

b) The voltage drop in the circuit, when carrying the highest load, should not exceed the limits specified for the circuits concerned (*see* in particular **10**);

*Relevant Indian Standards are under preparation.

†Specification for electrical installations in ships : Part 2 System design, Section 1 General.

c) After having been determined by the foregoing calculations, the cross-sectional area should be checked, taking into consideration the temperature-rise liable to be caused by short-circuits (*see* **14**) and motor starting currents (*see* **9**);

d) The mechanical strength of conductors should be sufficient for the installation and working conditions;

e) The cross-sections of the earth conductors should comply with IS : 10242 (Part 4)*;

f) Conductor-cross sections of less than 1 mm^2 shall not be used for power and lighting circuits; and

g) Conductor shall be of stranded construction.

NOTE — The tables incorporated in this standard for the current ratings and correction factors give only average values which are not exactly applicable to all cable constructions and all installation conditions existing in practice. They are nevertheless recommended for general application, considering that the errors (a few degrees Celsius in the estimated operating temperature) are of little importance against the advantages of having a single international standard for the evaluation of the current ratings. In particular cases, however, a more precise evaluation should be permitted, based on experimental or calculated data acceptable to all interested parties.

6. CURRENT RATINGS FOR CONTINUOUS SERVICE

a) Continuous service for a cable is to be considered, for the purpose of this standard, as a current-carrying service (with constant load) having a duration longer than three times the thermal time constant of the cable, that is, longer than the critical duration (*see* Fig. 1).

b) The current rating for continuous services recommended for single-core cables for various insulating materials are given in Table 1.

These current ratings are applicable, with fair approximation, whatever is the type of covering (for example, both armoured and unarmoured cables).

NOTE — All the values have been calculated for an ambient temperature of 45°C and assuming that a conductor temperature equal to the maximum rated temperature of the insulation is reached and maintained continuously in the case of a group of four cables bunched together and laid in free air (*see also* 8). For different conditions, *see* the following:

For two-, three- and four-conductor cables, the current ratings given in Table 1 should be multiplied by the following (approximate) correction factors:

1) 0·85 for twin cables, and

2) 0·70 for three- and four-core cables.

*Specification for electrical installation in ships: Part 4 Installation and tests of completed installations (*under preparation*).

TABLE 1 CURRENT RATINGS IN CONTINUOUS SERVICE FOR SINGLE-CORE CABLES (AMBIENT TEMPERATURE 45°C)

(*Clauses* 6, 7.1, 7.2, 7.3, 8.1 *and* 9)

Nominal Cross-Sectional Area	General Purpose PVC 60°C*	Heat Resisting PVC 75°C*	Butyl Rubber 80°C	EPR and XLPE 85°C*	Silicon Rubber and Mineral Insulation 95°C
(1)	(2)	(3)	(4)	(5)	(6)
mm²	A	A	A	A	A
1	8	13	15	16	20
1·5	12	17	19	20	24
2·5	17	24	26	28	32
4	22	32	35	38	42
6	29	41	45	48	55
10	40	57	63	67	75
16	54	76	84	90	100
25	71	100	110	120	135
35	87	125	140	145	165
50	105	150	165	180	200
70	135	190	215	225	255
95	165	230	260	275	310
120	190	270	300	320	360
150	220	310	340	365	410
185	250	350	390	415	470
240	290	415	460	490	—
300	335	475	530	560	—

*Maximum permissible service temperature of the conductor.

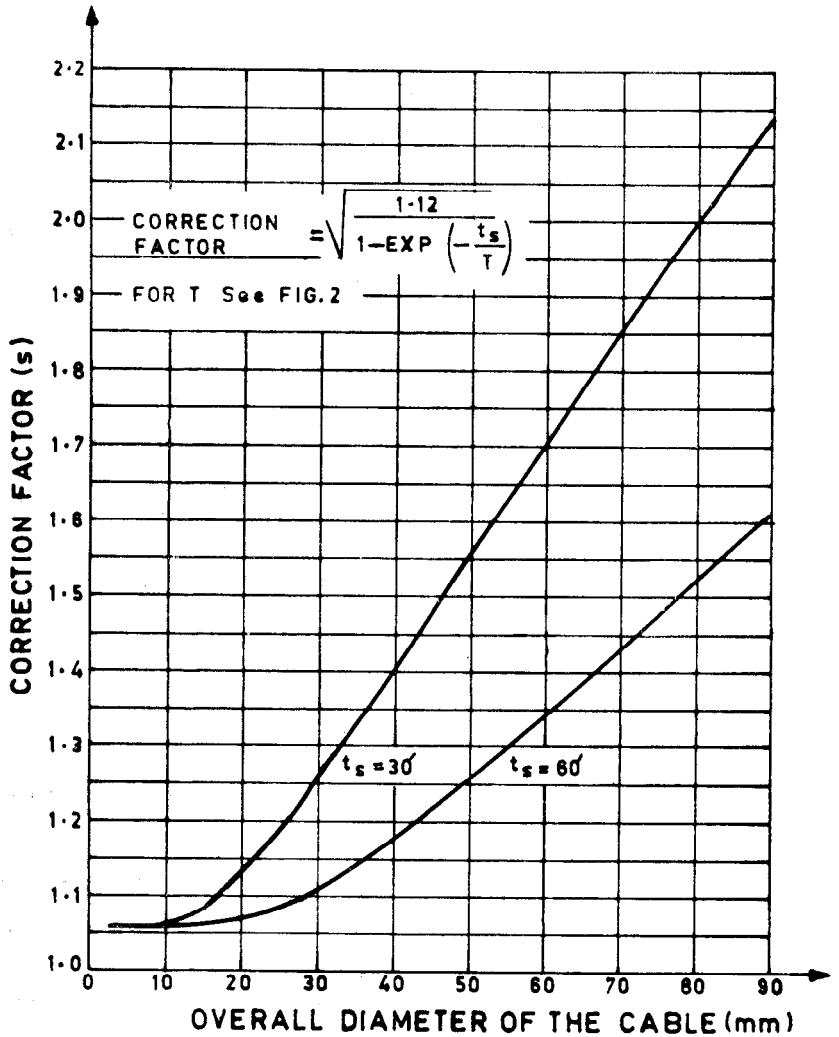
NOTE 1 — The current ratings I, in amperes, have been calculated for each nominal cross-sectional area A, in square millimetres, with the formula:

$$I = \alpha . A^{0.625}$$

where α is a coefficient related to the maximum permissible service temperature of the conductor as follows:

Maximum permissible temperature of the conductor		60°C	75°C	80°C	85°C	95°C
Values of α	For nominal cross-sectional area $\geq$ 2·5 mm²	9·5	13·5	15	16	18
	For nominal cross-sectional area $<$ 2·5 mm²	8	13	15	16	20

NOTE 2 — When a mineral insulated cable is installed in such a location that its copper sheath is liable to be touched by hand when in service, the current rating shown in column 6 should be multiplied by the correction factor 0·80 in order that the sheath temperature does not exceed 70°C.



t_s = Service time

FIG. 1 CORRECTION FACTORS FOR HALF-HOUR AND ONE-HOUR SERVICE

7. CORRECTION FACTORS FOR DIFFERENT AMBIENT AIR TEMPERATURES

7.1 The ambient temperature of 45°C, on which the current ratings in Table 1 are based, is considered as a standard value for the ambient air temperature, generally applicable for any kind of ship and for navigation in any climate.

7.2 When, however, ships for particular uses are considered (for instance, coasters, ferries, harbour craft) and the ambient temperature is known to be permanently lower than 45°C, the current ratings from Table 1 may be increased (but in no case should the ambient temperature be considered to be lower than 35°C).

7.3 When, on the other hand, it is to be expected that the air temperature around the cables could be higher than 45°C (for instance, when a cable is wholly or partly installed in spaces or compartments where great heat is produced or higher cable temperatures could be reached due to heat transfer), the current ratings from Table 1 should be reduced.

The correction factors for these cases are given in Table 2.

TABLE 2 CORRECTION FACTOR FOR VARIOUS AMBIENT AIR TEMPERATURES

Maximum Conductor Temperature (°C)	Correction Factors for Ambient Air Temperature of										
	35°C	40°C	45°C	50°C	55°C	60°C	65°C	70°C	75°C	80°C	85°C
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
60	1·29	1·15	1·00	0·82	—	—	—	—	—	—	—
65	1·22	1·12	1·00	0·87	0·71	—	—	—	—	—	—
70	1·18	1·10	1·00	0·89	0·77	0·63	—	—	—	—	—
75	1·15	1·08	1·00	0·91	0·82	0·71	0·58	—	—	—	—
80	1·13	1·07	1·00	0·93	0·85	0·76	0·65	0·53	—	—	—
85	1·12	1·06	1·00	0·94	0·87	0·79	0·71	0·61	0·50	—	—
90	1·10	1·05	1·00	0·94	0·88	0·82	0·74	0·67	0·58	0·47	—
95	1·10	1·05	1·00	0·95	0·89	0·84	0·77	0·71	0·63	0·55	0·45

8. CORRECTION FACTORS FOR CABLE GROUPING

8.1 The current rating values given in Table 1 (and those derived therefrom) may be considered applicable, without correction factor, for cables bunched together on cable trays, in cable conduits, pipes or trunking, unless more than six cables, which may be expected to operate simultaneously at

their full rated capacity, are laid close together in a cable bunch in such a way that there is, in absence of free air, circulation around them. In this case a correction factor of 0·85 should be applied.

NOTE — Cables are said to be bunched when two or more are contained within a single conduit, trunking or duct, or, if not enclosed, are not separated from each other.

9. CORRECTION FACTORS FOR SHORT-TIME DUTY

a) If a cable is intended to supply a motor or equipment operating for periods of half an hour or one hour, its current rating, as given by Table 1, may be increased using the relevant correction factors given by Fig. 2. These correction factors are applicable only if the intermediate periods of rests are longer than the critical duration (which is equal to three times the time constant of the cable), given in Fig. 1, as a function of the cable diameter.

NOTE — The correction factors given in Fig. 2, are approximate and depend mainly upon the diameter of the cable. In general, half-an-hour service is applicable to mooring winches, windlasses, heavy cargo winches and cowthrusters. The half-an-hour rating might not be adequate for automatic tensioning mooring winches and bowthrusters of specialized vessels.

b) For cables supplying a single motor or other equipment intended to operate in an intermittent service, as is generally the case for cargo winches (except heavy cargo winches), engine-room cranes and similar devices, the current ratings as given in Table 1 may be increased by applying the correction factor given by Fig. 3.

The correction factor given in Fig. 3 has been roughly calculated for periods of 10 min, of which 4 min are with a constant load and 6 min without load.

10. VOLTAGE DROP

10.1 The cross-sectional areas of conductors should be so determined that the drop in voltage from the main or emergency switchboard bus-bars to any and every point on the installation when the conductors are carrying the maximum current under normal conditions of service, does not exceed 6 percent of the nominal voltage. For supplies from batteries with a voltage not exceeding 50 V, this value may be increased to 10 percent.

10.2 For navigation lights it may be necessary to limit voltage drop to lower values in order to maintain required lighting output and colour.

10.3 The values are applicable under normal steady conditions. Under special conditions of short duration, such as motor starting, higher voltage drops may be accepted provided the installation is capable of withstanding the effects of these higher voltage drops.

11. ESTIMATION OF LIGHTING LOADS

11.1 In the assessment of the current rating of lighting points for the purpose of determining sizes of conductors, every lampholder should be deemed to require a current equivalent to the maximum load likely to be connected to it, and this should be assumed to be at least 60 W; except that, where lighting fitting is so constructed as to take only a lamp rated at less than 60 W, the current rating may be assessed accordingly.

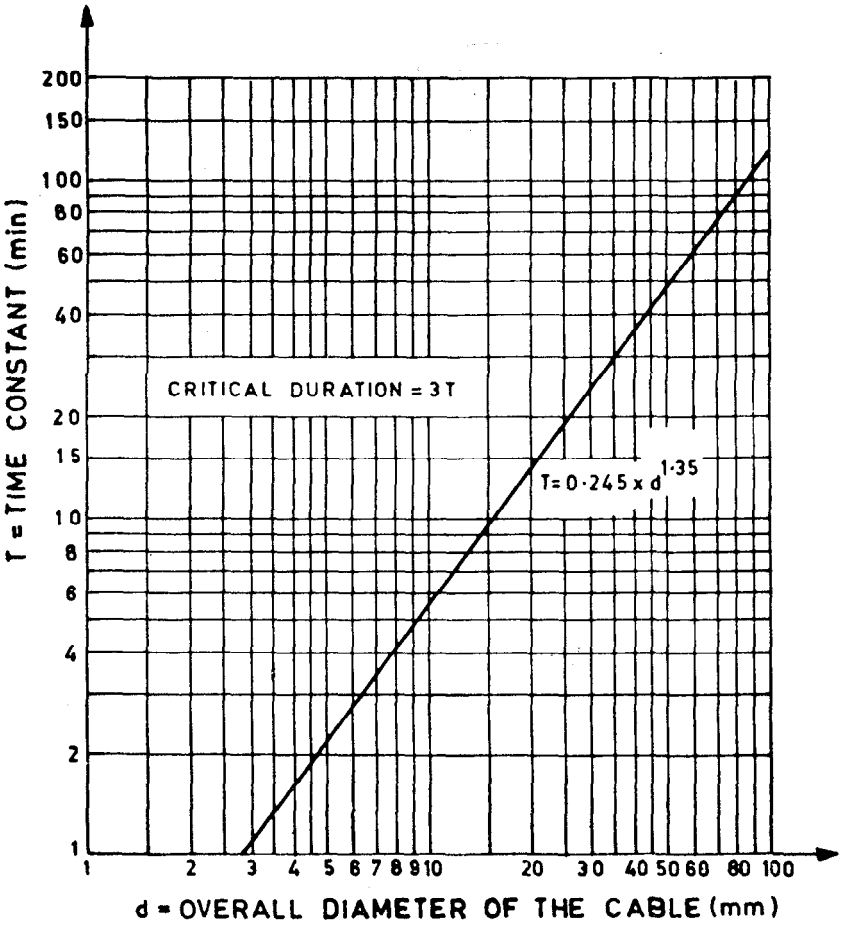
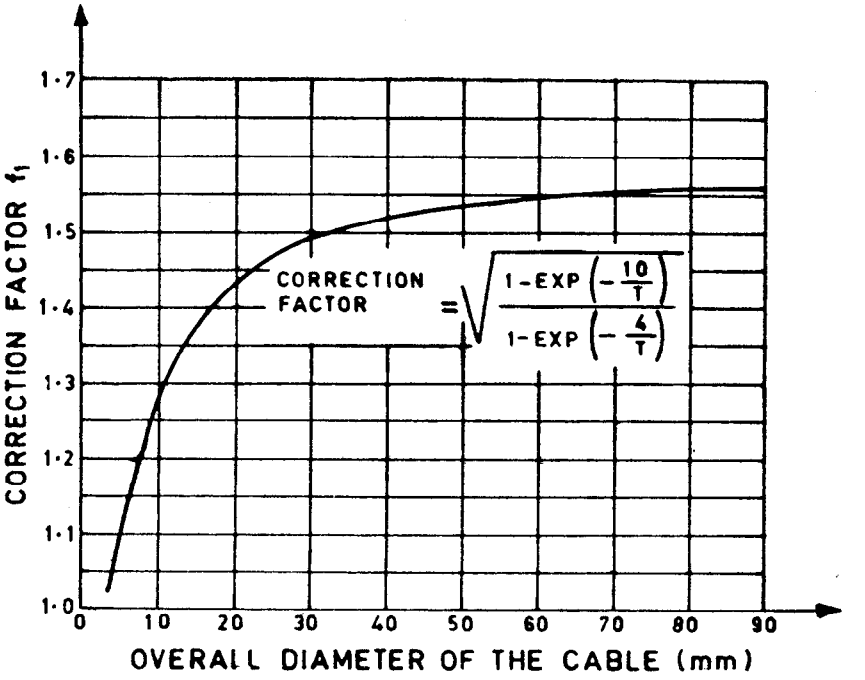


FIG. 2 TIME CONSTANT OF CABLES



Intermittence period = 10 min

Intermittence ratio = 40%

FIG. 3 CORRECTION FACTOR FOR INTERMITTENT SERVICE

11.2 Each lighting socket-outlet will count for two lighting points.

NOTE—Lighting branch circuits may also supply small galley equipment (such as toasters, mixers, coffee makers, etc) and small domestic equipment (such as desk fans, refrigerators, etc).

12. PARALLEL CONNECTION OF CABLES

12.1 The current-carrying capacity of cables connected in parallel is the sum of the current ratings of all parallel conductors provided the cables have equal impedance, cross-section and maximum permissible conductor temperatures. The connection in parallel will be permitted only for cross-sections of 10 mm^2 or more.

13. SEPARATION OF CIRCUITS

13.1 Separate cables are to be used for all circuits requiring individual short-circuit or overcurrent protection, except for circuits mentioned under (a) and (b).

a) A control circuit which is branched off from its main circuit (for example, for an electric motor) may be carried in the same cable as the main circuit provided the main circuit and the subsidiary control circuit are controlled by a common isolator.

b) Non-essential circuits with voltage not exceeding the 'safety voltage' as defined in IS : 10242 (Part 1/Sec 1)-1982*.

14. SHORT-CIRCUIT CAPACITY

14.1 Cables and their insulated conductors should be capable of withstanding the mechanical and thermal effects of the maximum short-circuit current which can flow in any part of the circuit in which they are installed, taking into consideration not only the time/current characteristics of the circuit protective device, but also the peak value of the prospective short-circuit current during the first half-cycle.

SECTION 12B INSTALLATIONS

15. CABLE RUNS

a) Cable runs should be selected so as to be as far as possible straight and accessible;

b) In the construction of cable runs, account should be taken of the need for protection against destructive pests or rodents;

c) Cables having insulating materials with different maximum permissible conductor temperature (*see* Table 2) should not be bunched in a common clip, gland, conduit, trunking or duct;

Where this is impracticable, the cables should be so selected that no cable reaches a temperature higher than its rating;

d) Cables having a protective covering which may damage the covering of more vulnerable cables should not be bunched with the latter in a common clip, gland, conduit, trunking or duct;

*Specification for electrical installation in ships : Part 1 General, Section 1 Definition and general requirements.

e) Cables having a bare metallic sheath or braid or armour should be installed in such a way that galvanic corrosion by contact with other metals is prevented;

f) Cables run should be selected so as to avoid action from condensed moisture or drip. Cables should, as far as possible, be remote from resources of heat, such as boilers, hot pipes and resistors, and protected from avoidable risks of mechanical damage. Where installation of cables near sources of heat cannot be avoided, and where there is consequently a risk of damage to the cables by heat, suitable shields should be installed, or other precautions to avoid over-heating should be taken, for example, use of special ventilation, installation of heat insulation materials, or use of special heat-resisting cables;

g) Cables should not be installed across expansion joints. If, however, it is unavoidable, a loop of cable having a length proportional to the expansion of the joint should be provided. The minimum internal radius of the loop during operation should never be less than twelve times the external diameter of the cable;

h) When cables are installed in bunches and the risk of fire propagation is high, special installation precautions should be taken to prevent fire propagation regardless of whether or not any or all of the cables are declared ' flame-retardant ';

j) In the case of essential electrical equipment for which it is mandatory to have at least two supplies, for example, steering gear installations, the supply and any associated control cables should follow different routes, which should be separated both vertically and horizontally as far as practicable.

k) Where it is required to divide a ship into fire zones (such as is generally the case on passenger ships), cable runs should be so arranged that a fire in any main-vertical fire zone will not interfere with essential services in any other such zone. This will be met if main and emergency cables passing through any zone are separated both vertically and horizontally as widely as is practicable; and

m) Cables and wiring serving essential or emergency power, lighting internal communications or signals should so far as practicable be routed clear of galleys, laundries, machinery spaces and their casings and other high fire risk areas, except for supplying equipment in those spaces.

Where possible they should be run in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

In respect of the prevention of fire damage to cables, special attention should be given to the protection of main cable routes for essential circuits as, for example, between machinery spaces and the navigation bridge area.

NOTE — Brief description of the terms used in cable installation is given in Appendix B.

16. CABLE INSTALLATION METHODS IN RELATION TO ELECTROMAGNETIC INTERFERENCE

16.1 In order to avoid as much as possible the effects of unwanted electromagnetic interference, attention should be given to electromagnetic compatibility of electric and electronic installations in ships (relevant Indian Standard is under preparation).

This might be of particular importance for the installation of cables in the vicinity of radio equipment and for the installation of cables belonging to sensitive electronic control and monitoring systems.

17. MECHANICAL PROTECTION

a) In situations where there could be a risk of mechanical damage, cables should be enclosed in suitable conduits or casings, unless the cable covering (for example, armour or sheath) provides adequate mechanical protection;

b) In situations where there would be an exceptional risk of mechanical damage, for example, in holds, storage spaces, cargo spaces etc, cables should be protected by steel casing, trunking or conduits, even when armoured, if the ship's structure or attached parts do not afford sufficient protection for the cables; and

c) Metal casing used for mechanical protection of cables should be efficiently protected against corrosion.

18. EARTHING OF METAL COVERINGS AND OF MECHANICAL PROTECTION OF CABLES

a) All metal coverings of cables should be electrically connected to the metal hull of the ship at both ends except in so far as the provisions given in **28.1** (a) apply. Single-point earthing is admitted for final sub-circuits (at the supply end) and in those installations (control and instrumentation cables, mineral insulated cable, intrinsically safe circuits, control circuits, etc) where it is required for technical or security reasons, if any;

b) Earthing connections should be carried out with conductors having cross-sectional area (*see* Part 4) related to the current ratings of the cables, or by equivalent means, such as metal clamps gripping the metal covering of the cable and connected to the metal hull of the ship;

The metal covering of cables may be earthed by means of glands intended for the purpose and so designed as to ensure an effective earth connection.

The glands should be firmly attached to, and in effective electrical contact with, a metal structure earthed in accordance with this standard;

c) The electrical continuity of all metal coverings throughout the length of the cables, particularly at joints and tappings, should be ensured;

d) The lead of lead-sheathed cables should never be used as the sole means of earthing non-current-carrying parts (*see* Part 4)*; and

e) Metal casings, pipes and conduits or trunking should be effectively earthed.

19. RADIUS OF BEND

19.1 The internal radius of bend for the installation of cables should be chosen according to the type of cable as recommended by the manufacturer and should not be less than the values given in Table 3.

TABLE 3 BENDING RADII

Cable Construction		Overall Diameter of Cable (D)	Minimum Internal Bending Radius
Insulation	Outer Covering		
(1)	(2)	(3)	(4)
Thermoplastic and elastomeric	Metal sheathed armoured and braided	Any	6 D
	Other finishes	$\leq$ 25 mm	4 D
		> 25 mm	6 D
Mineral	Hard metal sheathed	Any	6 D

20. FIXING

a) With the exception of cables for portable appliances and of those installed in pipes, conduits, trunkings or special casings, cables should be fixed by means of clips, saddles or straps of suitable flame-retardant material, and having a surface area so large and shaped that the cables remain tight without their coverings being damaged;

*Specification for electrical installation in ships : Part 4 Installation and test of completed installation (*under preparation*).

b) The distances between supports should be suitably chosen according to the type of cable and the probability of vibration, and should not exceed 40 cm, for a horizontal cable run where the cables are laid on cable supports in the form of tray plates, separate support brackets or hanger ladders, the spacing between the fixing points may be up to 90 cm, provided that there are supports with maximum spacing as specified above. This exemption should not apply to cable runs along weather decks, when the cable run is arranged so that the cables can be subjected to forces by water washing over the deck;

NOTE — When designing a cable support system for single-core cable consideration should also be given to the effects of electrodynamic forces developing on the occurrence of a short-circuit (27). The above given distances between cable supports are not necessarily adequate for these cables.

c) The supports and the corresponding accessories, should be robust and should be of corrosion-resistant material or suitably treated before erection to resist corrosion;

d) Cable clips or straps made from a material other than metal (such as polyamide, PVC, etc) may be used. Requirements concerning the characteristics of the material are under consideration; and

e) When cables are fixed by means of clips or straps referred in item (d) above and these cables are not laid on top of horizontal cable trays or cable support, suitable metal cable clips or saddles should be added at regular distances (for example, 1 m to 2 m) in order to prevent the release of cables during a fire. This also applies to the fixing of non-metallic conduits or pipes.

NOTE — Item (e) does not necessarily apply in the case of cable runs with only one or a few cables with small diameters for the connection of a lighting fitting, alarm transducers, etc.

21. CABLES PENETRATING BULKHEADS AND DECKS

a) Penetration of watertight decks and bulkheads should be effected in a watertight manner. Either individual stuffed glands or boxes containing several cables and filled with a flame-retardant packing may be used for this purpose. Whichever type of cable is used, the glands or boxes and the packing should be such that the assembly complies with a gland-watertightness test*.

NOTE — Care should be taken in choosing packings, to avoid cables being adversely affected (for example, by high temperature arising from the pouring of the compound, chemical reaction, etc).

*This test is under preparation.

b) Cables passing through decks should be protected to a suitable height above the deck.

c) If cables have to pass through non-watertight bulkheads and generally through holes drilled in sheets of structural steel, these holes should be fitted (if necessary in order to avoid damage to cables) with glands or bushings of any suitable material.

The choice of the materials used for glands and bushings should be such that there is no risk of corrosion or damage to the cables or to the ship's structural materials.

d) Vertical trunking for electrical cables should be so constructed as not to afford passage of fire from one between-deck or compartment to another.

e) Penetration of decks and bulkheads which are required to have some degree of fire integrity, should be so effected as to ensure that the required degree of fire integrity is not impaired.

f) The distance from cable penetration to flanges of steam or hot oil pipes shall not be less than 300 mm for stead/hot oil pipes with diameter *D*-75 mm and not less than 450 mm for larger pipes.

22. INSTALLATION IN METALLIC PIPES OR CONDUITS OR TRUNKING

22.1 When cables are installed in metal tubes, conduits or trunking, the following precautions should be observed [*see also* **15** (c) and (d) for bunching of cables]:

a) The pipes, conduits or trunking should be suitably smooth on the interior and protected against corrosion;

b) The pipes or conduits or trunking should have their ends shaped or bushed in such a way as not to damage the cable covering;

c) The pipes or conduits or trunking should have such internal dimensions and radius of bend as will permit the easy drawing in and out of the cables which they are to contain: the internal radius of bend should be not less than those permitted for cables (*see* **19**) and, for pipes exceeding 63 mm external diameter, not less than twice the external diameter of the pipe;

d) Pipes, conduits and trunking should be effectively earthed;

e) Pipes, conduits and trunking should be so arranged that water cannot accumulate inside them (account being taken of possible condensation);

f) The space factor (ratio of the sum of the cross-sectional areas corresponding to the external diameters of the cables to the internal cross-sectional area of the pipe or conduit or trunking) should not be greater than 0·4;

g) If necessary, ventilating openings should be provided, preferably at the highest and lower points, so as to permit air circulation and to obviate the possibility of water accumulating at any part of the pipe, conduit or trunking run. This may be done only if the fire-risk will not be increased thereby;

h) Drawing of lead-sheathed cables without any covering into tubes, conduits or trunking is to be avoided;

j) If there is reason to fear that a tube may break because of its length, appropriate expansion joints should be provided. This might be the case when cable pipes are fitted along weather-decks;

k) Where cables are to be drawn into pipes or conduits or trunking, draw boxes should be installed, where necessary, in order to ensure that the cables are not damaged during installation; and

m) In the case of pipes for use on open deck and in water and fuel oil tanks, the following minimum wall thickness of pipes shall apply:

Internal diameter of pipe (*mm*)	*Minimum wall thickness* (*mm*)
$\leqslant$ 57·0	4·0
57·0 $\leqslant$ 152·4	4·5
152·4 $\leqslant$ 304·8	5·5

NOTE — Special requirements apply to use of pipes on open deck and in water and fuel oil tanks and cofferdams.

23. INSTALLATION IN NON-METALLIC PIPES, CONDUITS, TRUNKING, DUCTS OR CAPPING AND CASING

23.1 Cables may be installed in non-metallic pipes, conduits, trunking, ducts or casings either on surface or concealed behind ceiling or panelling, provided the following precautions are observed:

a) All cables or insulated wiring should be 'flame-retardant';

b) If the fixing of capping is by means of screws, they should be of non-rusting material arranged so as not to damage the cables. The capping should be readily accessible;

c) Non-metallic pipes, conduits, trunkings, ducts or cappings and casings should be flame-retardant in accordance with IS : 10242 (Part 1/Sec 1) - 1980* and secured in accordance with **20** (e);

*Specification for electrical installations in ships: Part 1 General, Section 1 Definitions and general requirements.

d) Cables should be fixed, if necessary, with clips as described in **20**; and

e) The precautions recommended in **15** (c) and (d) should be observed also for installation in non-metallic casings.

24. INSTALLATION IN BATTERY COMPARTMENTS

24.1 Installation of cables in rooms assigned to batteries only should be avoided as far as possible [*see* IS : 10242 (Part 4)*]. If, however, such an installation is necessary, the cables should have a protective covering resistant to the vapours developed by the electrolyte and the bulk-head penetration should be gas-tight.

25. INSTALLATION IN REFRIGERATION SPACES

a) Cables to be installed in refrigeration spaces should include an impervious sheath and should be protected against mechanical damage. Cables insulated or sheathed with PVC should not be used in refrigerator spaces unless the relevant PVC compounds are appropriate to the low temperature expected.

If the armour is made of non-corrosion-resisting material, it should be protected against corrosion by a moisture-resisting and low-temperature resisting covering;

b) Cables installed in refrigeration spaces should not be covered by thermal insulation. They shall be so placed as to leave a space between the cables and the face of the refrigeration chamber. If a cable has thermoplastic or elastomeric extruded sheath, it may be placed directly on the face of the refrigeration chamber. The casual use of cables as a means of suspension should be obviated by the provision of guards surrounding the cables.

Care should be taken to avoid the possibility of electrolytic action if the refrigeration chamber has an aluminium facing; and

c) If the cables must pass through the thermal insulation of the compartments, they should do so at right angles, in tubes provided with entries of material protected against oxidation.

26. TENSILE STRESS

26.1 Cables should be so installed that the tensile stress applied to them either by reason of their own weight or for any other reason, is minimized†.

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*Specification for electrical installations in ships: Part 4 Installation and test of completed installation (*under preparation*).

†Specification on the maximum allowable mechanical stress on the conductors is under preparation.

26.2 Those precautions are particularly important for cables of small cross-section and for cables on vertical runs, or in vertical pipes. The cable should be suitably supported.

27. ELECTRODYNAMIC FORCES

27.1 In order to guard against the effects of electrodynamic forces developing on the occurrence of a short-circuit, single core cables should be firmly fixed, using supports of strength adequate to withstand forces corresponding to the values of prospective short-circuit currents.

28. SPECIAL PRECAUTIONS FOR SINGLE-CORE CABLES FOR AC WIRING

28.1 AC wiring should be carried out, as far as possible, in twin or multicore cables. When however, it is necessary to use single-core cables for circuits rated in excess of 20A, the following precautions should be observed:

a) The cables should either be non-armoured or they should be armoured with non-magnetic material.

   In order to avoid current loops the metallic screen should be earthed at one point only.

b) Conductors belonging to the same circuit should be contained within the same pipe, conduit or trunking, or the clamps which fix them should include all the phases, unless they are made of non-magnetic material.

c) In the installing of two, three or four single-core cables forming respectively single-phase circuits, three-phase circuits, or three-phase and neutral circuits, the cables should, as far as possible, be in contact with one another.

   In every case, the distance measured between the external covering of two adjacent cables should not be greater than one cable diameter.

d) When single-core cables having a current rating greater than 250A must be installed near a steel bulkhead, the clearance between the cables and the bulkhead should be at least 50 mm, unless the cables belonging to the same ac circuit are installed in trefoil formation.

e) Magnetic material should not be used between single-core cables of a group. Where cables pass through steel plates, all the conductors of the same circuit should pass through a plate or gland, so made that there is no magnetic material between the cables, and clearance between cables and magnetic material should not be less than 75 mm, unless the cables belonging to the same ac circuit are installed in trefoil formation.

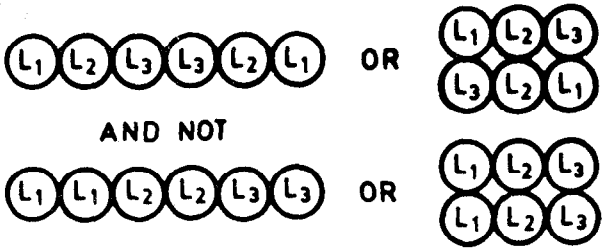
f) In order to equalize to some degree the impedance of three-phase circuits of considerable length consisting of single-core cables of a conductor cross-section of 185 mm² or over, a transposition of the phases should be effected at intervals not exceeding 15 m.

Alternatively, the cables may be installed in trefoil formation.

The above precautions are, however, not necessary when the length of the run is less than 30 m.

g) In circuits involving several single-core cables in parallel per phase, all cables should follow the same route and have the same cross-sectional area.

Further, the cables pertaining to the same phase should be as far as practicable alternated with those of the other phases so that unequal division of the current is avoided. For instance, in case of two cables per phase, correct dispositions are:



29. CABLE ENDS

a) Where mechanical clamps are not used, the ends of all cable conductors should be fitted with soldering sockets or compression-type sockets of sufficient size to contain all thes trands of the conductor. Where soldering is adopted, corrosive fluxes should not be used [*see* IS : 10242 (Part 3/Sec 2)-1984*].

b) All protective coverings should be removed for at least 13 mm from the ends of the insulation but not more than necessary. For mineral cables, *see* (h) .

c) Cable sockets and connecting terminals should be of such design and dimensions that the maximum current likely to flow through them will not produce heat which would be injurious to the insulation. In general, the temperature should not exceed that allowed for the cable in relation to the insulation.

*Specification for electrical installations in ships : Part 3 Equipment, Section 2 Switchgear and controlgear assemblies.

d) In the case of cables with a supplementary insulating belt beneath the protective sheath, at the ends where the belt has been removed, an additional insulation shall be added at the points where the insulation of each core enters, or may enter, into contact with earthed metal.

e) The fixing of conductor in terminals at joints and at tappings should withstand the thermal and dynamic effects of short-circuit currents.

f) When required, cable ends should be marked for identification.

g) The ends of mineral-insulated cables should be prepared in accordance with the instructions issued by the manufacturers of these cables.

h) Cables not having a moisture-resistant insulation (for example, mineral-insulated) should have their ends effectively sealed against ingress of moisture.

30. JOINTS AND TAPPINGS (BRANCH CIRCUITS)

a) Cable runs should not normally include joints. If, in the case of repair or sectional construction of the ship, a joint is necessary, the joint should be of such a type that electrical continuity, insulation, mechanical strength and protection, earthing and fire-resisting of flame-retardant characteristics are not less than those required for the cables;

b) Tappings (branch circuits) should be made in suitable boxes, of such design that the conductors remain suitably insulated and protected from atmospheric action, and fitted with terminals or busbars of dimensions appropriate to the current rating; and

c) Joints and tappings should be clearly marked to identify the cable(s) and core(s).

31. JOINT BOXES

31.1 Live parts should be mounted on durable flame-retardant moisture-resistant material, of permanently high dielectric strength and high insulation resistance.

31.2 The live parts should be so arranged by suitable spacing or shielding with flame-retardant insulating material, that a short-circuit cannot readily occur between conductors of different polarity or between conductors and earthed metal.

31.3 Joint boxes should be made of flame-retardant material. Joint boxes should be clearly identified defining their function and voltage.

APPENDIX A

[*Clause* 3 (d)]

NOTE ON SHEATHING MATERIALS FOR CABLES WITH LIMITED FIRE HAZARD PROPERTIES

A-1. INTRODUCTION

A-1.1 Cables which become involved in fires may contribute to the overall fire hazard by the generation of heat and flammable gases which aid propagation of fire and by emission of airborne products. Moreover:

a) *Smoke* — results in loss of vision, hampers escape and fire fighting.

b) *Acid Gases* — results in corrosion hazard to precision electronic equipment in addition to steel structure.

c) All gases results in toxic hazard.

All the polymers used in cables will either degrade or burn if exposed to sufficient heat. When formulating a sheathing with improved reaction to fire properties, the objective is to reduce specific potential hazards, that is, it is most desirable that the cable sheath:

a) will be more difficult to ignite,

b) if ignited will propagate flame less quickly,

c) will contribute less smoke,

d) will emit products which are less corrosive, and

e) will emit fewer and less toxic gases.

A-1.2 Various parameters which have a bearing on flame propagation properties of the sheathing material have been described below:

a) *Oxygen Index* — This is defined to be the minimum concentration of oxygen in a mixture of oxygen and nitrogen (expressed as percentage) which will support candle like burning of a specimen for at least three minutes or until 50 mm (two inches) of the sample has burnt.

b) *Smoke Density* — This is a method to determine the extent to which plastic/elastomeric materials are likely to generate smoke under conditions of active burning and decomposition in the presence of flame.

The measurements are made in terms of loss of light transmission through a collected volume of smoke produced under controlled, standardized conditions. The apparatus is constructed so that the flame and smoke can be observed during the test.

c) *Acid Gas* — The tests specifies the method for the determination of the amount of halogen acid gas, other than hydrofluoric acid evolved during the combustion of compounds based on halogenated polymers and compounds containing halogenated additives taken from the cable constructions.

d) *Flame Tests* — The test procedure specifies the determination of flame propagating properties under various conditions of usage.

e) *Toxicity Index* — The toxicity index is to be expressed in terms of 10 metres of sheathed wire sample and is a measure of the toxic gases produced during combustion.

f) *Temperature Index* — Test procedure defines the behaviour of material at elevated temperatures.

A-2. TEST METHODS

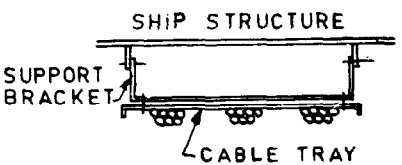
A-2.1 The test methods for checking these parameters shall be subject to agreement between the purchaser and the supplier.

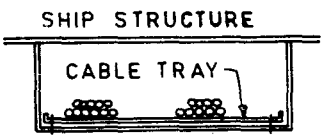
APPENDIX B

(*Clause* 15)

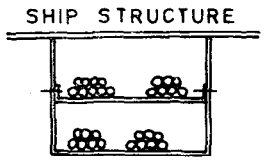
TERMINOLOGY

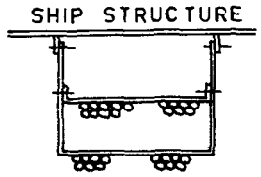
Term	*Material*	*Description*
Cable way	—	Space allocated on a vessel for cable installation
Cable support techniques	—	A variety of methods exist and are dependent upon the type of vessel, yard installation practices, etc
Cable racks	—	Land term used to describe a particular method of cable installation
Cable tray	Plastic, metal	Perforated cable plate which is supported from ship structure. Cables are laid on top of the plate or supported below the cable tray

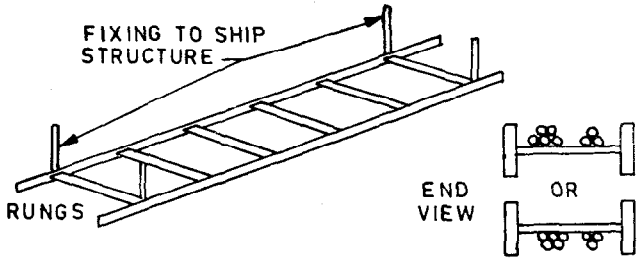


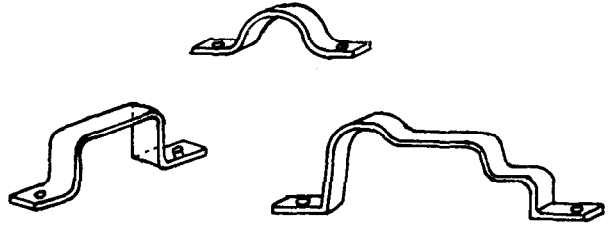


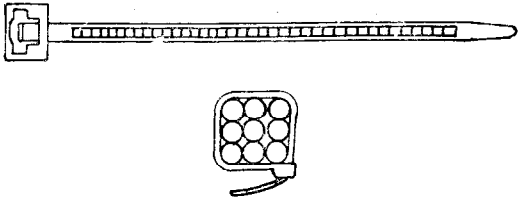
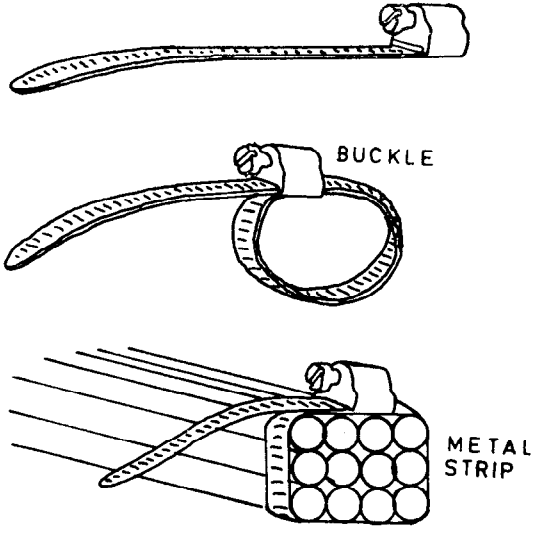
Cable hanger	Metal	In this system the cables are laid on top of the cable hangers which are attached or bolted to ship structure. Alternatively the cables are supported below the hanger
Ladder rack	Metal	In this system the ladder is constructed from flat section metal bars and is usually available in standard lengths. The ladder is attached to the ships structure. Cables are either laid on top of the ladder rungs or attached to the rungs
Cable clip saddle	Plastic, metal	These are usually preformed and used to hold the cables onto cable plates, trays, ladder racks or hangers



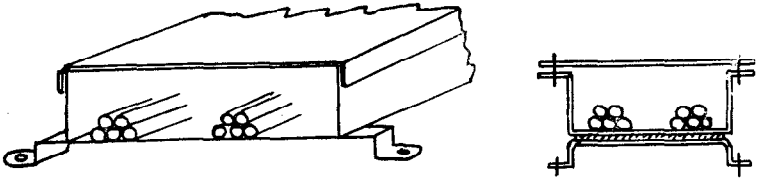




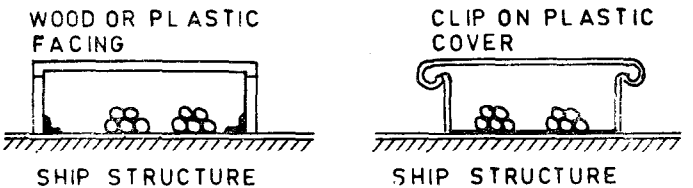


Term	*Material*	*Description*	
Cable strap or tie	Plastic	A wide range of straps and ties are available and nearly all operate on the same principle, the strap or tie has a buckle through which the free end of the tie is passed for fixing	
Cable band	Metal	Metal strip which is used as the method of holding groups of cables together, the metal strip being tensioned and terminated in a buckle	

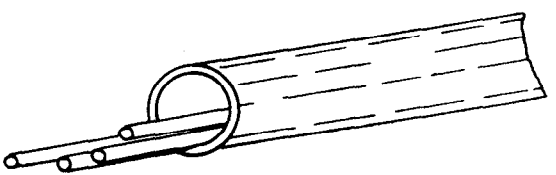
Trunking, ducting	Metal, wood, plastic	Trunking or ducting is usually of square or rectangular section having one side on the top of the section removable for access to cables



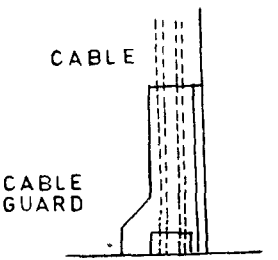
Capping, casing	Wood, plastic	Wood capping is normally used to cover cables in accommodation areas in an attempt to match the decor of the cabin, etc. Plastic casing is an alternative and no attempt is made at colour matching

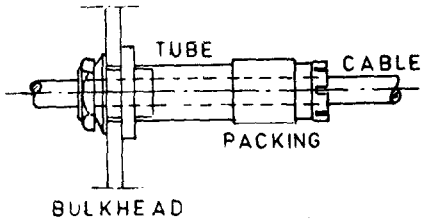
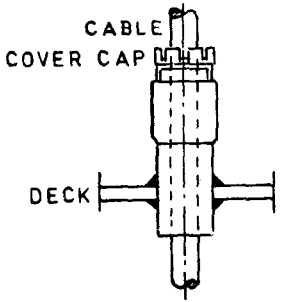
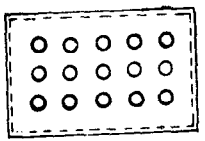
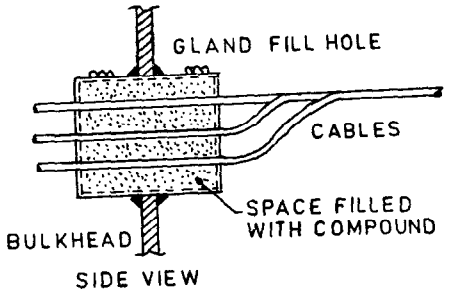


Pipe, conduit	Metal, plastic	Usually of circular cross-section used to provide mechanical protection or cable support, or both



Term	*Material*	*Description*
Cable guard	Sheet metal	Material used depends upon the application and probability of mechanical damage. The cover plate being fitted only where damage is likely to occur
Cable glands	—	Basically there are two gland applications: 1) cables passing through ship structure, deck or bulkheads; 2) cable entering equipment



Deck gland, bulkhead gland	Metal	A pipe penetrates the deck or bulkhead and the cable pass through the pipe. The space between the cable and pipe bore is filled to preserve the watertight integrity of the space	 
Multi-gland	Metal	Where many cables pass through a bulkhead or deck then a multigland is used. Some are commercially available, others are made at the shipyards	 

Term	*Material*	*Description*
Duct	Metal	A duct is used where there is requirement to protect the cables passing through a deck. The duct is usually made from metal pipe or fabricated from metal plate
Equivalent glands	—	The type of gland used depends upon the application and the type of cable
Plastics cable glands	Polyamide or other plastics	A wide range of glands is available of varying materials
Metal cable gland	Metal	Again a wide range is available and provide means of terminating the armoured, screened sheaths of cables